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NOTES ON GINKGO BILOBA¹

WALTER W. TUPPER

(WITH PLATE XX)

Among the gymnosperms, one of the groups most interesting from a morphological standpoint is the Ginkgoales, the only living representative of which is *Ginkgo biloba*, or maidenhair tree of China and Japan. This group is of special importance and value to the morphologist because of the close resemblance which its reproductive characters bear to those of the Archigymnospermae, and the many ways in which its vegetative anatomy resembles that of the lower conifers. Thus, the modern *Ginkgo biloba* forms the connecting link between the lower conifers and the Archigymnospermae. The presence of well-marked annual rings, and of opposite pits with bars of Sanio on the tracheids, and the absence of either terminal or diffuse xylem parenchyma in the branch of *Ginkgo* are some of its characters which show its close relationship with the pinelike or lower conifers.

During this last year, the writer has made some studies of the wood and short shoots of *Ginkgo*. Perhaps the most striking characteristic of the anatomy of the wood is the presence and distribution of crystal cells and wood parenchyma. SEWARD and GOWAN² say that in a fairly old root the medullary rays contain a few crystal sacs, and that the wood parenchyma also includes some crystal-containing cells. Nowhere in their paper do they refer to the peculiar arrangement of the xylem parenchyma, nor is it shown by any of their plates. In another part of this same paper they describe the occurrence of swollen parenchymatous cells, full of crystals, in the secondary bast, cortex, pith, and medullary ray tissues. Nothing peculiar, however, is noted regarding

¹ Contributions from the Phanerogamic Laboratories of Harvard University, no. 34.

² SEWARD, A. C., and GOWAN, MISS J., The maidenhair tree (*Ginkgo biloba* L.). *Annals of Botany* 14:135. 1900.

their distribution. PENHALLOW,³ GOPPERT,⁴ and others have described the existence of crystal cells, or idioblasts, in the branch of *Ginkgo*, and PENHALLOW has even added that they occur scattered throughout the wood and often in vertical series.

From a careful examination of the root, I have found that these idioblasts, or crystal-containing cells, and parenchyma cells invariably occur in longitudinal rows, or series, which run from ray to ray. In every single case these parenchyma and crystal cells were found in relation with a ray, as is shown in figs. 1, 2, and 3.

Fig. 1 is a radial section of the wood of the root, and shows the large, round, crystal cells, or idioblasts, in a longitudinal row connecting two rays. To the side of and intermingled with the crystal cells of this row are parenchyma cells, some of which appear as appendages of the rays. These parenchyma cells apparently give rise to the crystal cells, or else are modified into them. Some of the crystal cells are torn, due to the fact that the crystals of calcium oxalate which they contained were not fully dissolved by treating with hydrofluoric acid. The crystal cells are seen in contact with a ray in a tangential view in fig. 3.

The Ginkgoales are the connecting link between the Archi- and Metagymnospermae, possessing, as they do, motile sperm cells and other reproductive characters of the Archigymnospermae, together with anatomical characteristics of the Metagymnospermae, such as clearly marked annual rings, bars of Sanio, opposite pits on their tracheids, and only vestigial traces of centripetal wood (in their foliar organs). The wood parenchyma, however, is related to the rays, and extends in *radial* rows, unlike the *tangentially* distributed wood parenchyma found in the conifers. Wood parenchyma, like annual rings, appears to have been produced by woody plants as a reaction to the arrival of winter conditions in the geological and climatic evolution of the earth. Figs. 2 and 4, the former a radial, the latter a transverse section of the *Ginkgo* root, also show the peculiar distribution of the xylem parenchyma and crystal cells.

Like the Pineae, probably the oldest conifers, *Ginkgo* has its

³ PENHALLOW, D. P., A manual of the North American gymnosperms. p. 209. 1907.

⁴ GOPPERT, H. R., Monographie der Fossilen Coniferen. p. 266. 1850.

leaves borne on short shoots. One of the most noticeable things about the short shoots of *Ginkgo* is the fact that quite frequently they branch within the wood of the limb out of which they grow. In fig. 5 we have a transverse section of a branching short shoot, showing the two divisions entirely separate from each other, yet still within the wood of the branch. Fig. 6 shows this same branching short shoot sectioned nearer the pith, with the short shoot not yet divided.

SEWARD and GOWAN (*l.c.* p. 132) say that in some instances the short shoot of *Ginkgo* may branch like the trunks of *Cycas*. To illustrate this they have reproduced a natural-sized cut (*l.c.* pl. 9, fig. 42) of a branching short shoot. The branching to which they refer, however, takes place entirely outside of the wood of the limb, as is shown by their figures.

It is of special interest in this connection to note that a new araucarian conifer, *Woodworthia*, from the Triassic of the Fossil Forest of Arizona, which has been examined and described by Professor JEFFREY⁵ has short shoots which likewise divide within the wood of the branch. This gives us convincing evidence that the araucarian conifers are an old group, and have possibly come from the same stock as the Ginkgoales. Unlike the short shoots of *Ginkgo*, those of the araucarian conifer mentioned apparently never grew out into long shoots.

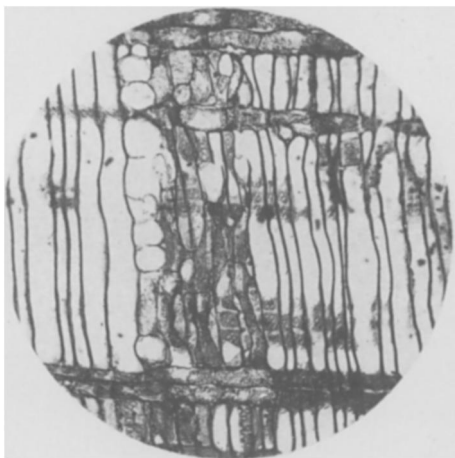
Like the Ginkgoales and araucarian conifers, the older Abietineae likewise had short shoots. It would be interesting, were the material available, to examine the short shoots and woody branches of *Prepinus*, the probable ancestor of the Abietineae, in search for branching within the wood of the limb.

Summary

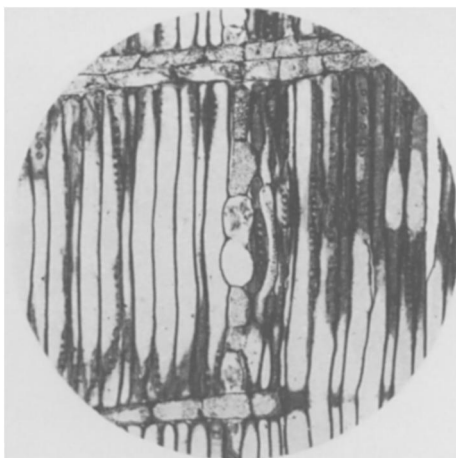
The root of *Ginkgo biloba* contains crystal cells and wood parenchyma distributed in rows or series which run longitudinally throughout the root in radial planes.

All of these rows of cells are in contact with at least one ray. In some places the wood parenchyma cells can be distinguished

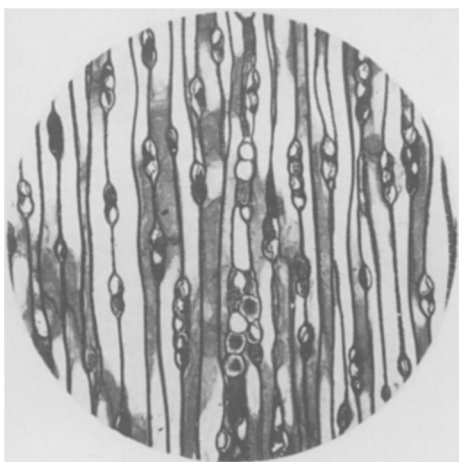
⁵ JEFFREY, E. C., Proc. Boston Soc. Nat. Hist. 34: pls. 31, 32. 1910.



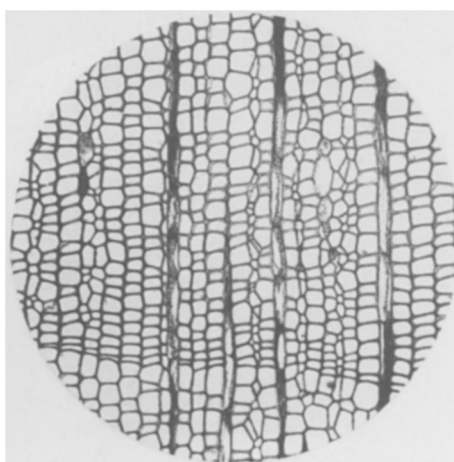
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2



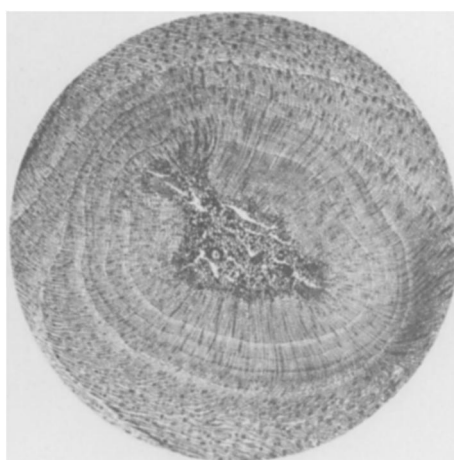
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4



5



6

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as appendages of the rays. The crystal-containing cells seem to be a modification of the parenchyma cells.

The fact that all of the xylem parenchyma found in *Ginkgo* is very differently distributed from that found in the conifers (radial and not tangential) suggests that it is a primitive type.

The short shoots of *Ginkgo* frequently divide within the wood of the branch. The only one of the conifers which is known to have such a peculiarity is the new araucarian genus *Woodworthia*.

This work has been done in the Phanerogamic Laboratories of Harvard University. The writer is indebted to Professor JEFFREY for advice and guidance throughout the investigation, and for aid in securing the accompanying photomicrographs.

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EXPLANATION OF PLATE XX

Ginkgo biloba

FIG. 1.—Radial section of root, showing crystal-containing cells in contact with a ray, and distributed in a row (intermingled with parenchyma cells) which runs longitudinally along the root; parenchyma growing out from rays; $\times 80$.

FIG. 2.—Radial section of root, showing two rays connected by a row of crystal cells; $\times 80$.

FIG. 3.—Tangential section of root; $\times 80$.

FIG. 4.—Transverse section of root; $\times 80$.

FIG. 5.—Transverse section of branching short shoot, showing the divisions entirely separate from each other, yet still within the wood of the branch; $\times 12$.

FIG. 6.—Transverse section of branching short shoot seen in fig. 5, sectioned nearer in toward the pith of the branch, showing the short shoot undivided; $\times 12$.